ENGIE

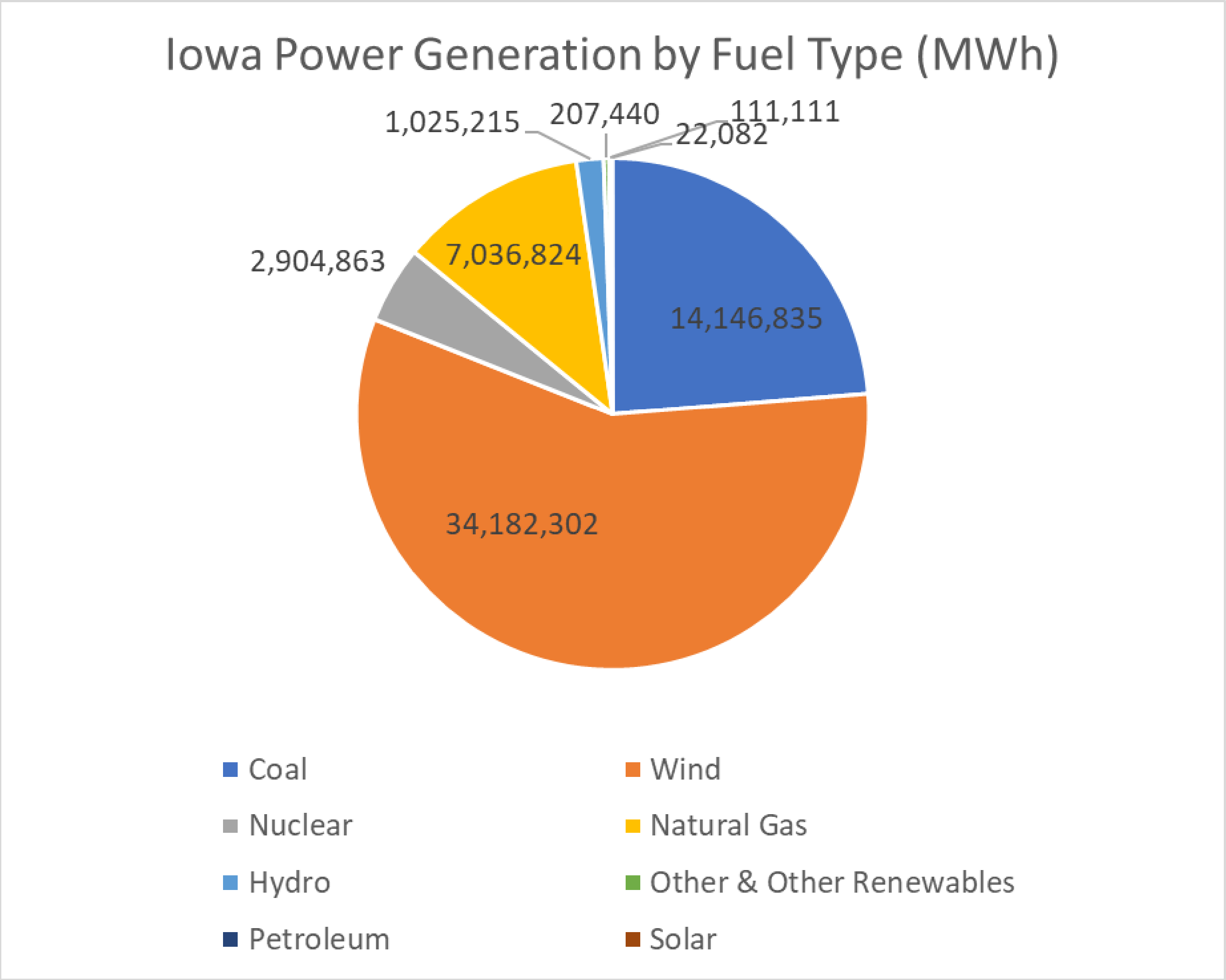
UIOWA
HACKATHON
#hackuiowa

ENGIE Hackathon Challenge

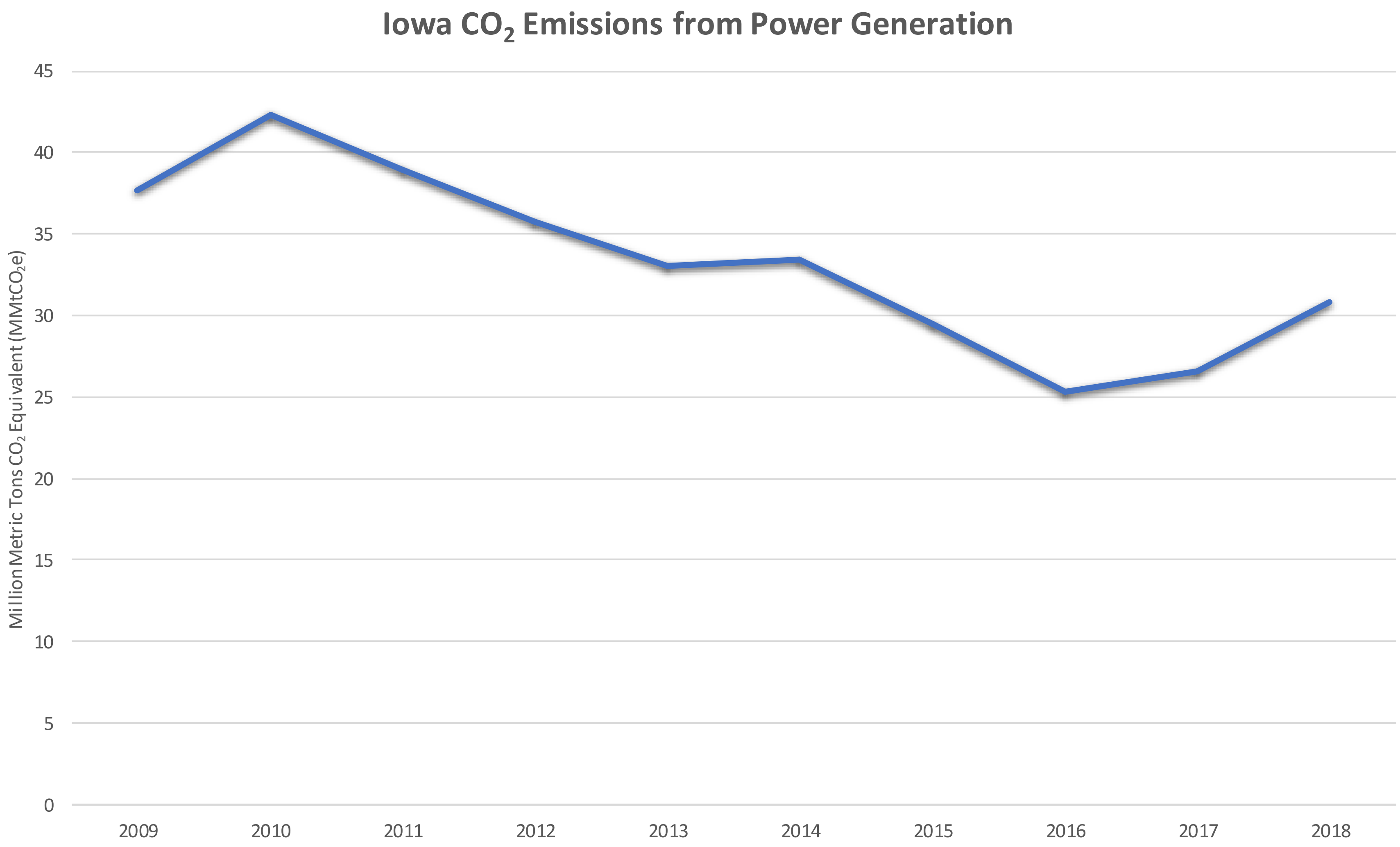
Premise

As residents of Iowa, we know this is a windy place, and over the past 20 years the state has taken advantage of wind for power generation in a big way. Over half of the total power produced in Iowa is sourced from the ~12 GW of nameplate wind capacity installed here, making Iowa one of the cleanest power generating states on average. However, the wind doesn’t blow all the time, and sometimes electric demand increases much more than normal, mostly due to weather. In these times, the state must rely on fossil fuels to keep the grid energized, which results in meaningful emissions. Emissions are *time sensitive*. The grid can go from very clean to very dirty very quickly.

In addition to supplying electricity, the University must provide heating and cooling that is not produced electrically. Heating and a portion of the cooling are currently produced on campus by burning various fuels, some of which are cleaner than others. The University also has the option to generate a portion of its electricity which at any given time may be cleaner or dirtier than purchasing electricity from the grid.



So, let's just keep building more wind, right? Unfortunately, if we want to also have reliability, the marginal benefit of more and more wind declines, because the wind resource is intermittent. We may already have as much wind capacity as we can reasonably use: the declining trend of CO_2 emissions from power generation may have already bottomed out in 2016.



One of the best opportunities to continue greening up the state's energy profile, though, is through "negawatts", or time-based conservation measures to reduce electric load at times when the state's emissions profile is dirty. The key challenge to accomplish this revolves around knowing when this is happening and acting on that information. ENGIE, the operator of the University of Iowa's utility system, needs your help in this area.

The Challenge

Create a dashboard that will help ENGIE respond to the grid's emissions profile more effectively. There are three levels of this challenge, based on how valuable and actionable the information is.

ENGIE staff will be available on site to clarify details of the challenges and explain all associated support material.

The Challenge: Level 1

(Open to all students*)

BACKTEST

Correlate the daily historical campus energy load with daily historical CO_2 emissions.

Daily energy load is composed of two components; purchased electricity and consumed fuels such as natural gas, coal, energy pellets and oat hulls.

Daily historical CO_2 emissions can be calculated by multiplying each energy input to the campus by its corresponding CO_2 factor(s). These inputs include all consumed fuels and all purchased electricity. Include purchased electricity and consumed fuels for both the Main and Oakdale campuses. This analysis would help ENGIE devise a program to reduce non-critical loads at the right times to improve the campus sustainability profile.

*File containing 1 year of historical campus data provided

The Challenge: Level 2

(Team must have at least one U of I student for data access*)

DASHBOARD

Create a real-time dashboard of the campus CO2 emission profile, showing each campus energy component's contribution to CO2. Use available information from MISO API's to break out CO2 by each generation component on the electrical grid. See slide "Data on Electrical Grid Information" for list of API's and link to conversion factors.

Note: API for generation from Petroleum Fuel is not currently available, so may assume this component is zero for development purposes.

*Student must have HawkID to access data system

The Challenge: Level 3

(Team must have at least one U of I student for data access*)

Predictive Model

One way to reduce our carbon footprint (total CO2 emissions from levels 1 and 2 above) is to reduce overall energy demand. This load reduction is challenging when no advance notice is available. With some planning, much more load reduction is possible than without it. In this challenge, develop an AI model to predict the campus energy load (all consumed fuels and purchased electricity from levels 1 and 2 above) 24 hours in-advance so that the campus will have time to evaluate potential operational changes to reduce load that will have a sustainability benefit.

Some sense of the magnitude of the benefit and statistical confidence is also required for the information to be actionable. As a bonus, try to develop a model of the carbon footprint 24 hours in advance.

HINT You will likely want to correlate weather data with backtest data from level 1.

*Student must have HawkID to access data system

GHG Calculation Details – Scope 1

Greenhouse Gas Calculation Emission Factors

Fuel	Heat Content Conversion	HCC Units of Measure	CO_2 Factor (kg CO_2 per mmbtu)	CH_4 Factor (g CH_4 per mmbtu)	N_2O Factor (g N_2O per mmbtu)	Biogenic CO_2 Factor (kg Biogenic CO_2 per mmbtu)
Natural Gas	0.001026	mmbtu/cf	53.06	1	0.1	
Pellets*	20.89375	mmbtu/short ton	31.875	32	4.2	67.94775
Oat Hulls	8.25	mmbtu/short ton		32	4.2	118.17
Coal	24.93	mmbtu/short ton	93.28	11	1.6	
Sorbent			**CO_2 Factor (Metric CO_2 per short ton limestone sorbent)**			
Limestone Sorbent			0.4			

Source: EPA, "Emission Factors for Greenhouse Gas Inventories," Table 1 Stationary Combustion Emission Factors, March 9, 2018 (https://www.epa.gov/climateleadership/center-corporate-climate-leadership-ghg-emission-factors-hub).

*Emission Factors for Pellets is a calculated value based on material combination provided by ENGIE.

GHG Calculation Details – Scope 2

Location Based Data

Summary Data | US EPA

eGRID2020 Summary Tables (epa.gov)

Location Based	CO_2 Factor Lb/MWh	CH_4 Factor Lb/MWh	N_2O Factor Lb/MWh
State – IA	611.1	0.06	0.009

- Typically, greenhouse gas emissions are reported in units of carbon dioxide equivalent (CO_2e). Gases are converted to CO_2e by multiplying by their global warming potential (GWP). The emission factors listed in this document have not been converted to CO_2e. To do so, multiply the emissions by the corresponding GWP listed in the table below.

Gas	100-Year GWP
CH_4	25
N_2O	298

Source: Intergovernmental Panel on Climate Change (IPCC), Fourth Assessment **Report (AR4), 2007.**

- Other Conversion Factors
  - 1 short ton = 2000 lbs
  - 1 klb = 1 thousands pounds = 1000 lbs
  - 1 kg = 1000 g
  - 1 metric ton = 1000 kg
  - 1 pound = 453.592 gram

Fuel Consumption Available From U of I PI Data Historian

Natural Gas	Engineering Units	Comments
PP_TB1_2_WCB3_Scaled_Gas_Flow	SCF/HR	flow measurement
HBLR_GAS_FLOW	KSCF/HR	flow measurement
PP_B7_Gas_Flow_Adj	KSCF/HR	flow measurement
PP_B8_Gas_Flow_Adj	KSCF/HR	flow measurement
PP_B10_FLT_235_FT	SCF/HR	flow measurement
PP_AF-XI-8220A	KSCF	Value is set at approximately midnight with previous day's total.
PP_BLR12_FT_006_KSCFH	KSCF/HR	flow measurement
PP_GG1_FUEL_FLOW	SCF/Min	flow measurement
PP_GG2_FUEL_FLOW	SCF/Min	flow measurement
PP_GG3_FUEL_FLOW	SCF/Min	flow measurement
PP_GG4_FUEL_FLOW	SCF/Min	flow measurement
Oakdale		See data file for example on how to calculate
Boiler 10 Pellets		
PP_CHS_B10WeighBelt_MvgAvg	thousands of pounds/hr	flow measurement
PP_CHS_B10WeighBelt_TotalizedWeight	thousands of pounds	Continuously increments
Boiler 11 Coal and Pellets		
PP_SF-WIT-6044A	thousands of pounds/hr	flow measurement
Boiler 11 Oat Hulls		
PP_BIO_Weight	thousands of pounds/hr	flow measurement
PP_B11OHTOTY	thousands of pounds	Value is set at approximately midnight with previous day's total.

Campus Purchased and Generated Electricity

Main Campus Purchased Electricity		
PP_Electric_Purch	MW	power measurement
Main Campus Electrical Generation		
PP_Electric_Gen	MW	power measurement
Oakdale Purchased Electricity		
SUBO-69K.3351.EA-734.MW	MW	power measurement
Oakdale Campus Electrical Generation		
SUBO-PP1.3351.GN1-734.MW	MW	power measurement
SUBO-PP1.3351.GN2-734.MW	MW	power measurement
OAK_DG3_Real_Power	KW	power measurement

Data on Electrical Grid Generation

MISO Generation

Visually browse the EIA.gov API here (no key required): https://www.eia.gov/opendata/v1/qb.php

Register for a key here: https://www.eia.gov/opendata/register.php

Relevant Endpoints:

Hourly MISO Wind Generation: https://api.eia.gov/series/?api_key=API-KEY-HERE&series_id=EBA.MISO-ALL.NG.WND.H&start=20220816T14Z

Hourly MISO Solar Generation: https://api.eia.gov/series/?api_key=API-KEY-HERE&series_id=EBA.MISO-ALL.NG.SUN.H&start=20220816T14Z

Hourly MISO Hydro Generation: https://api.eia.gov/series/?api_key=API-KEY-HERE &series_id=EBA.MISO-ALL.NG.WAT.H&start=20220816T14Z

Hourly MISO Coal Generation: https://api.eia.gov/series/?api_key=API-KEY-HERE&series_id=EBA.MISO-ALL.NG.COL.H&start=20220816T14Z

Hourly MISO Natural Gas Generation: https://api.eia.gov/series/?api_key=API-KEY-HERE&series_id=EBA.MISO-ALL.NG.NG.H&start=20220816T14Z

Hourly MISO Nuclear Generation: https://api.eia.gov/series/?api_key=API-KEY-HERE&series_id=EBA.MISO-ALL.NG.NUC.H&start=20220816T14Z

Hourly MISO Petroleum Generation (has issues, might be deprecated): https://api.eia.gov/series/?api_key=API-KEY-HERE&series_id=EBA.MISO-ALL.NG.OIL.H&start=20220816T14Z

Hourly MISO Other Generation: https://api.eia.gov/series/?api_key=API-KEY-HERE&series_id=EBA.MISO-ALL.NG.OTH.H&start=20220816T14Z

The &start=20220816T14Z parameter is restricting the data to the last 30 days, otherwise it will try to pull all the data and it will be very slow.

To get carbon accounting, just multiply the datapoints by the coefficients here: https://www.eia.gov/tools/faqs/faq.php?id=74&t=11. For the “Other” use the average of 0.85 pounds of CO_2 per KWH.

Source for Historical Local Weather Data

http://johnson.weatherstem.com/uiowa

Data → Data Mining to create CSV File with historical weather data.

HELPFUL LINKS

- PI Web API Documentation

https://itsnt2259.iowa.uiowa.edu/piwebapi/help/getting-started

- How to make API Call in C# (You may use any method/language you like)

https://medium.com/bgl-tech/how-to-make-your-first-get-api-call-in-c-net-core-501134ee6e19

Steps to use API to retrieve Data Point Info

- Access the PI WEB API with

https://itsnt2259.iowa.uiowa.edu/piwebapi/

- Enter UIowa Hawk ID and password when prompted for authentication
- PI WEB API uses Basic Authentication

EXAMPLE Retrieving point
PP_BLR12_FT_006_KSCFH

- Use Query API Call and change end of URL depending on Data point

https://itsnt2259.iowa.uiowa.edu/piwebapi/search/query?q=name:PP_BLR12_FT_006_KSCFH

- Click on "Self" or use this API Call for links to given Data Point

https://itsnt2259.iowa.uiowa.edu/piwebapi/points/F1DPSeBeuukhFUGh_VBA7Ni8Pwb3sAAAUElTRVJWRVIuRkFDSUxJVElFUy5VSU9XQS5FRFVcUFBfQkxSMTJfRlRfMDA2X0tTQ0ZI

Current and Interpolated Data

- Click on "Value" for current Data point value or use this API Call

https://itsnt2259.iowa.uiowa.edu/piwebapi/streams/F1DPSeBeuukhFUGh_VBA7Ni8Pwb3sAAAUElTRVJWRVIuRkFDSUxJVElFUy5VSU9XQS5FRFVcUFBfQkxSMTJfRlRfMDA2X0tTQ0ZI/value

- Click on "Interpolated Data" for values over the specified time range at the specified sampling interval.

https://itsnt2259.iowa.uiowa.edu/piwebapi/streams/F1DPSeBeuukhFUGh_VBA7Ni8Pwb3sAAAUElTRVJWRVIuRkFDSUxJVElFUy5VSU9XQS5FRFVcUFBfQkxSMTJfRlRfMDA2X0tTQ0ZI/interpolated/?startTime=-1m&endTime=-2w&interval=1d

- Edit end of URL to change time range

- startTime default = *-1d

- endTime default = *

- Interval default = 1h

Time String Documentation: https://itsnt2259.iowa.uiowa.edu/piwebapi/help/topics/time-strings

Summary Data

Click on "SummaryData" or use this API Call with parameters for the summary over the specified time range for the stream

https://itsnt2259.iowa.uiowa.edu/piwebapi/streams/F1DPSeBeuukhFUGh_VBA7Ni8Pwb3sAAAUElTRVJWRVIuRkFDSUxJVElFUy5VSU9XQS5FRFVcUFBfQkxSMTJfRlRfMDA2X0tTQ0ZI/summary/?startTime=-1d&summaryDuration=1h&summaryType=Average

Use this API Call for Total Summary Data:

- https://itsnt2259.iowa.uiowa.edu/piwebapi/streams/F1DPSeBeuukhFUGh_VBA7Ni8PwQgIAAAUElTRVJWRVIuRkFDSUxJVElFUy5VSU9XQS5FRFVcUFBfU0YtV0lULTYwNDRB/summary/?startTime=-1d&summaryDuration=1h&summaryType=Total

NOTE: With Total Data, Value must be multiplied by conversion factor.

Conversion factor is based on units per day.

Ex. If unit/hour then conversion factor is *24. If Unit/minute conversion factor is *1440.

- Alter end of URL based off Documentation with necessary fields
- Summary Data Documentation:

https://itsnt2259.iowa.uiowa.edu/piwebapi/help/controllers/stream/actions/getsummary